ANALOG MODULAR SYSTEM A-100

General Adjustment Procedure for VCOs

The adjustment procedure is very similar for all VCOs and consists of these steps:

- Temperature adjustment, provided that the VCO in question includes such a circuitry
- **1V/octave scale adjustment**
- High frequency tracking adjustment, provided that the VCO in question includes such a circuitry
- **Frequency offset adjustment**
- Adjustment of the waveform converter(s), provided that the VCO in question includes such a circuitry
- Adjustment of the range switch, provided that the VCO in question includes such a circuitry

Only items 2 (scale) and 4 (offset) are available for all VCO circuits.

Item 1 (temperature adjustment) is available only for VCO circuits which use a heater to keep the VCO core at a certain temperature or for other temperature compensation circuits (e.g. A-110-1, A-110-2, A-110-4, A-110-6). Circuits with special VCO chips like CEM3340 do not required such an adjustment.

Item 2 (1V/octave scale) is probably the most important part of the adjustment as it defines the musical intervals of an VCO which are usually controlled by an external control voltage that follows the 1V/octave standard, i.e. a voltage difference of 1.00V of the control voltage corresponds to a pitch difference of exactly one octave.

Item 3 (high frequency tracking) is available only for certain VCO circuits which offer this feature (e.g. all CEM3340 based circuits).

Item 4 (frequency offset) is usually the last step of the adjustment and defines the absolute frequency (e.g. 65 Hz for the neutral positions of all controls which corresponds to a "C", but that's not mandatory).

Item 5 (waveform converters) is available only for VCO circuits which contain discrete waveform converters. These are used to derive e.g. a triangle from a sawtooth (e.g. A-110-1, A-110-2) or the other way round. Circuits with special chips like CEM3340 do usually not require such an adjustment as the internal waveform converters are already optimized.

Item 6 (range switch) is available only for VCOs circuits which contain a range switch. Rotary or toggle switch are used and work normally as octave switches. The corresponding trimming potentiometer has to be adjusted so that the intervals generated by the switch are exact octaves.

Required equipment

At least a **precise 1V/octave voltage source** is required as one needs very precise voltages to adjust the scale of the VCO. The control voltage should span at least 5V with a precision of at least 0.1%.
E.g. a midi-to-CV converter can be used, provided that it offers the required precision and voltage range.

A **frequency meter** that shows exactly the frequency of the VCO output is extremely helpful. Even a modern oscilloscope with precision frequency display can be used.

A (guitar) tuner is not very helpful because such tools usually do not show absolute frequencies but only the deviations from ideal musical tones. Especially in the beginning of a VCO adjustment the generated frequencies are far away from these ideal values and it would be very longwinded and time-consuming to use such a tool for VCO adjustment. That's why these tools are not recommended.

Another excellent "measuring tool" is the human ear. Especially for the recognition of octave intervals a trained good sense of hearing is unbeatable.

Short form of the adjustment process

- *If applicable: adjust the temperature control circuit as described in the technical document of the VCO in question (refer to the detailed description if necessary).*
- Connect the precision CV source to the 1V/octave CV input of the VCO.
- Adjust the trimming potentiometer which is responsible for the 1V/octave scale so that 1.000V CV intervals (e.g. 0 → +5.000V) correspond to exact octave intervals (e.g. 5 octaves for 0 → +5V), the absolute frequencies are not important for this adjustment, the absolute frequency is adjusted later with the trimming potentiometer which is responsible for the frequency offset (see below).
- *If applicable: Adjust the trimming potentiometer which is responsible for the high frequency tracking adjustment, this trimming is used to correct possible small aberrances from the ideal 1V/octave scaling for higher frequencies (typ. 5kHz an higher).*
- Adjust the trimming potentiometer which is responsible for the frequency offset to the desired value. There are no fixed rules for this adjustment but usually the absolute frequency is adjusted to a "C" (e.g. 65 Hz or 32 Hz or 130 Hz) with neutral settings of the manual frequency controls at the front panel (e.g. center position of tune, fine tune or octave switch if available).
- *If applicable: adjust the trimming potentiometer which is responsible for the adjustment of the waveform converter (refer to the detailed description if necessary).*
- *If applicable: adjust the trimming potentiometer which is responsible for the adjustment of the range switch so that the intervals generated by the switch are exact octaves (refer to the detailed description if necessary).*

Detailed description of the adjustment process

1. Temperature adjustment (if applicable)

This adjustment is a bit different for each VCO with such a circuitry. Please contact us directly when you need details for this part of the measurement.

Here is the example for the A-110-1 VCO:

> *Disconnect one of the two pins of R48 so that the connection between pin 6 of IC3/CA3046 and the output of O2 (pin 7/IC1) is interrupted. Turn on the module at normal room temperature (about 22 degrees Celsius) and measure the voltage at the non inverting input of O2 (pin 5/IC1). This is the temperature voltage at room temperature.*
>
> *Important: The module has to be disconnected from power about 20 minutes before you measure the voltage. Otherwise there may be some remaining heat inside the CA3046 transistor array. The temperature inside the CA3046 must be room temperature!*
>
> *Disconnect the module from power and connect both pins of R28 so that the connection between pin 6 of IC3/CA3046 and the output of O2 (pin 7/IC1) is re-established. Connect the module to power supply and wait about 5 minutes. Measure the temperature voltage (pin 5/IC1) again and adjust the temperature trimming potentiometer P9 until the voltage is 60mV below the voltage measured at room temperature. The voltage will be about 0.63V.*

Here is the example for the A-110-2 VCO:

> *The temperature voltage is adjusted to 0.62...0.63V by means of P10. It can be measured between the terminal named "VT" (below the CA3083 between R39 and C14) and GND.*

For other VCOs please contact hardware@doepfer.de for details concerning the temperature adjustment.

2. Scale adjustment (1V/octave)

Make sure that the used CV source is very precise and outputs a voltage that follows exactly the 1V/octave standard. Otherwise the VCO adjustment will be not correct. It's a good idea to measure the control voltage simultaneously with a precision meter (at least 4 ½ digits). For example the measured control voltage difference for 5 octaves should be exactly 5.000V.

- Connect the CV source to the 1V/octave CV input of your VCO.
- Connect one of the VCO outputs to the frequency meter (or scope with frequency display)
- Set the CV source to 0V and read the frequency (e.g. 47Hz)
- Set the CV source e.g. to 5.000V and read the frequency. The exact frequency should be 5 octaves higher (i.e. 1504 Hz in the example as each octave corresponds to frequency doubling). With an unadjusted VCO the real frequency will differ from this value (e.g. 1580 Hz – i.e. the upper frequency is too high, or 1475 Hz – i.e. the upper frequency is too low).
- Now operate the trimming potentiometer of the VCO which is responsible for the 1V/octave scale. Usually that's multiturn type and you may start e.g. with a 90 degrees turn. At this time one does not know if one has to turn the trimming potentiometer clockwise or counterclockwise. So one has to try out one direction.
- After this one has to compare again the frequencies for 0V and 5V CV. If the results are better as before the trimming potentiometer was turned in the right direction (e.g. 45Hz/1530Hz). Otherwise it was the wrong direction (e.g. 49Hz/1610Hz) and one should use the other direction to obtain better results.
- This procedure has to be repeated several times until the desired exact 5 octave interval is reached (e.g. 43Hz → 1376 Hz). As one comes closer to the exact interval the rotation angle of the trimming potentiometer is reduced little by little to not overshoot the adjustment.
- As a rule it's easier to start with the upper octave when it comes to fine scale adjustment (i.e. read the frequency corresponding to 5V CV) and then go to the lower octave (i.e. read the frequency corresponding to 0V CV)
- It's also helpful to use the manual tuning control of the VCO to start with a frequency value that is easier to memorize and easier to calculate the frequencies of the octaves below. If you e.g. adjust the manual

tuning control so that the upper frequency value is 1600 Hz it much easier to find the octaves below (800Hz, 400Hz, 200Hz. 100Hz, 50Hz) compared to an odd starting value like 1589Hz.
- The mentioned 5V/5 octave difference is only an example. One may also use 4 or 6 octave intervals (provided that frequency range of the VCO in question is sufficient)

3. High frequency tracking (if applicable)

Adjust the trimming potentiometer which is responsible for the high frequency tracking adjustment, this trimming is used to correct possible small aberrances from the ideal 1V/octave scaling for higher frequencies (typ. 5kHz an higher)

4. Frequency Offset adjustment (absolute tuning)

Adjust the trimming potentiometer which is responsible for the frequency offset to the desired value. There are no fixed rules for this adjustment but usually the absolute frequency is adjusted to a "C" (e.g. 65 Hz or 32 Hz or 130 Hz) with neutral settings of the manual frequency controls at the front panel (e.g. center position of tune, fine tune or octave switch if available).

5. Waveform converter adjustment (if applicable)

Adjust the trimming potentiometer which is responsible for the adjustment of the waveform converter

Here is the example for the A-110-1 VCO:

> *Trimming potentiometer P10 is used for adjusting the sawtooth-to-triangle converter. Connect the triangle output to an oscilloscope and adjust P10 for best triangle waveform. The small needle pulse and the small plateau of the triangle waveform result from the schematics design and will not fully disappear while adjustment of P10. From musical point of view these inaccuracies are of no significant meaning. CEM3340 based VCOs do not have these inaccuracies.*

For other VCOs please contact hardware@doepfer.de for details concerning the waveform converter adjustment.

6. Range switch adjustment (if applicable)

Adjust the trimming potentiometer which is responsible for the range switch adjustment so that the intervals generated by the switch become exact octaves.
Some VCOs use rotary switches (e.g. A-110-1, A-111-1, A-111-2), others use toggle switches (e.g. A-110-2, A-111-4, A-111-5, A-111-6). Some VCOs don't feature range switches (e.g. A-110-4, A-110-6, A-111-3).
When rotary switches are used typically only one trimming potentiometer is available. When toggle switches are used even separate trimming potentiometers for octave up and down may be available.

VCF Adjustment

The adjustment procedure for VCFs is very similar to VCOs but usually only **frequency scale** and **frequency offset** adjustments are available (i.e. steps 2 and 4 of the VCO adjustment).

The easiest way to adjust a VCF is to bring it to self oscillation so that it works like a sine VCO. Then the trimming potentiometers for frequency scale and frequency offset are adjusted in the same way as for a VCO.

A few VCFs have additional trimming potentiometers. E.g. the A-106-5 has two trimming potentiometers labeled "DC OFFSET 1" and "DC OFFSET 2". These are used to minimize the DC offset voltages at the outputs BP and LP.

Trimming potentiometer table for VCOs

VCO	Scale	Offset	High frequeny	Temp.	Waveform	Range
A-110-1	P7	P6	P8	P9	P10	P5
A-110-2	P5	P6	P7	P10	-	P8 (+), P9 (-)
A-110-4	P7	P6	-	P10	-	-
A-110-6	P6	P5	P7/P8	P9	-	-
A-111-1	P9	P7	P8	-	-	P10
A-111-2	P8	P9	P10	-	P11/P12 (sine)	P13
A-111-3	P4	P5	P6	-	P7: triangle DC offset P8: saw DC offset P9: rect. DC offset	-
A-111-4	P13, P16, P19, P22	P11, P14, P17, P20	P12, P15. P18. P21	-	-	P23
A-111-5	P17	P18	-	-	-	P19(+), P20 (-)
A-111-6	P14	P13	-	-	-	P12 (+), P11 (-)
Dark Energy I / II / III	P17	P18	-	-	-	P19(+), P20 (-)

Trimming potentiometer table VCFs

VCO	Scale	Offset	Others
A-101-1	P12	P11	P9: Resonance Scale, P10: Resonance Offset
A-101-2	P4	P6	
A-101-3	P6	P7	
A-101-6	P6	P7	P8/P9: Feedback
A-101-8	P7	P6	P8: Feedback
A-102	P7	P6	
A-103	P7	P6	
A-105	P7	P8	P6: Symmetry, P9: Q Offset
A-106-1	P10	P9	
A-106-5 V1/V2	P7	P6	P8: DC Offset BP/P9: DC Offset LP/HP
A-106-5 V3/V4	P7	P6	P9: DC Offset BP/P8: DC Offset LP/HP
A-106-6 V1/V2/V3/V4	P7	P6	P1 (Board B): HP adjustment
A-107	P12	P13	
A-108	P7	P6	
A-109	P10	P11	
A-120	P7	P6	P8: Resonance
A-121	P7	P8	
A-121s	P1/P3	P2/P4	
A-121-2	P6	P7	
A-121-3	P6	P5	
A-122	P7	P6	
A-123	P7	P6	P8: Control Voltage Feedthrough
A-123-2	P7	P6	P8: Control Voltage Feedthrough
A-124	P7	P6	
A-125	P7	P6	
A-127 V1…V3	P7	P6	
A-127 V4	-	P6	
Dark Energy I / II / III	P21	P22	